Alien Invasive Species and Biological Pollution

of the

Great Lakes Basin Ecosystem

May 2001

Great Lakes Water Quality Board

Report to the International Joint Commission

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Alien Invasive Species and Biological Pollution of the Great Lakes Basin Ecosystem

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of the International Joint Commission

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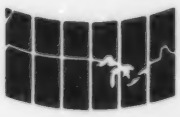

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Table of Contents

Summary		1
I.	Introduction	3
II.	Alien Invasive Species in the Great Lakes Basin Ecosystem	4
III.	International Joint Commission and Alien Invasive Species	6
IV.	Ballast Water and Alien Invasive Species	7
V.	The Great Lakes Water Quality Agreement and Alien Invasive Species	12
VI.	Ballast Water and NOBOBs	13
VII.	Treatment Alternatives for Ballast Water	14
VIII.	Recommendations	16
IX.	References	21

Acknowledgements ~ Photo and Illustration Use

Page 4, top	Center for Great Lakes and Quatic Species
Page 4, bottom	from *Integrated Pest Management for Nuisance Exotics in Michigan Inland Lakes*, Department of Fisheries and Wildlife, Michigan State University
Page 5, top	Center for Great Lakes and Aquatic Species
Page 5, bottom	from *Integrated Pest Management for Nuisance Exotics in Michigan Inland Lakes*, Department of Fisheries and Wildlife, Michigan State University
Page 7, top	from *Integrated Pest Management for Nuisance Exotics in Michigan Inland Lakes*, Department of Fisheries and Wildlife, Michigan State University
Page 7, middle	U.S. Army Corps of Engineers, Jerry Bielicki
Page 7, bottom left	Bill Kovalak
Page 7, bottom right	Don Schloesser
Page 8, top	Mills, E. et al., Journal of Great Lakes Research 19(1): 1-54. 1003, 1993.
Page 8, bottom	Lloyd's Register of Shipping
Page 10	1999 Annual Report of Lake Carrier's Association
Page 14	Don Schloesser, from *Aquatic Nuisance Species Handbook for Government Officials*, Michigan Department of Environmental Quality
Page 20	Center for Great Lakes and Aquatic Species
Cover, top left	U.S. Army Corps of Engineers, Jerry Bielicki
Cover, top right	Bruce Jamieson
Cover, bottom left	Center for Great Lakes and Quatic Species
Cover, bottom right	from *Integrated Pest Management for Nuisance Exotics in Michigan Inland Lakes*, Department of Fisheries and Wildlife, Michigan State University

Summary

The Great Lakes have been invaded by a succession of nonindigenous aquatic species, displacing important native species, interfering with beneficial human water uses and costing billions of dollars to control. Sources of alien invasive species to the Great Lakes basin include aquaculture, escapes from aquaria, ornamental ponds and research and educational facilities, canal and diversion water flows and release of live bait.

The discharge of ballast water from vessels coming from outside the U.S. and Canadian Exclusive Economic Zone, however, has been identified as the single most important source for alien invasive species entering the Great Lakes basin. Even more problematic is the fact that approximately 80 percent of the vessels entering the Great Lakes basin report "no ballast on board" (NOBOBs), thereby exempting them from current ballast water requirements, even though they typically contain a significant residual quantity of unpumpable ballast water and sediment. Available data indicate that living aquatic organisms in the residual ballast water have the potential to become successfully established when the residual ballast water is mixed with inflowing water and subsequently discharged in the Great Lakes basin.

In view of the serious environmental and economic consequences associated with nonindigenous or alien aquatic species becoming established in the Great Lakes via ballast water exchange, including the potentially-significant role of NOBOBs in this process, the Great Lakes Water Quality Board recommends a series of fundamental actions be undertaken to address this problem:

- *As the core of a preventative, binational approach for addressing the serious threat of alien invasive species (AIS) in the Great Lakes basin, the Commission should recommend to the Parties that effective binational ballast water discharge standards be developed, implemented and enforced throughout the Great Lakes basin as rapidly as possible. Further, the Commission should recommend the Parties prohibit the discharge of ballast water of any type into the Great Lakes basin from ballasted vessels and from vessels reporting no ballast on board (NOBOBs), whatever their origin, that do not meet the binational standards while they are within the Great Lakes basin.*

- *To aid in achieving the binational ballast water discharge standards, the Commission should recommend that the Parties, in cooperation with shippers and other relevant stakeholders, facilitate an immediate and significant investment in resources directed to the development of effective, long-term ballast water treatment technologies (e.g., filtration, ultraviolet light, heat, ozone), either onboard vessels or through onshore facilities. The Parties should also facilitate research directed to studying the life cycles of alien species with the greatest potential for invading the Great Lakes basin ecosystem, including identification of their potential interactions with, and impacts on, indigenous aquatic species.*

- *Until acceptable long-term treatment technologies are developed for treating ballast water to achieve the binational discharge standards, the Commission should recommend that the Parties give serious consideration to chemical treatment of ballast water as a short-term, emergency measure for all vessels entering the Great Lakes from outside the Exclusive Economic Zone. To facilitate the short-term, emergency use of chemical treatment, the Commission should recommend that the Parties, in cooperation with shippers and other relevant stakeholders, undertake appropriate testing and evaluation activities*

to determine the efficacy of alternative chemicals, including effective biocide chemical dosages, relative costs, onboard handling requirements and vessel safety, and potential environmental impacts of treated ballast water discharges. The Parties should develop and apply a uniform protocol for evaluating the results from the testing and evaluation program for application throughout the Great Lakes basin.

- *The Commission should recommend to the Parties that shippers and other relevant stakeholders immediately implement best management practices for ballast tank sediment control for all vessels entering the Great Lakes basin. The Commission should also recommend that the Parties undertake a program to publicly recognize the efforts of shippers engaged in good management practices.*

- *The Commission should recommend to the Parties that, as rapidly as possible, shippers incorporate vessel design modifications as appropriate for existing and new vessels, as a means of facilitating ballast water exchange on the open seas, and the effectiveness of other measures being considered (e.g., chemicals, filtration, ultraviolet light, heat) for treating ballast water to meet binational discharge standards. The Commission should also assist the Parties as appropriate in their interactions with the International Maritime Organization on the issue of vessel design modifications as a means of addressing the problem of alien invasive species in ballast water.*

- *The Commission should recommend that the Parties develop and implement effective contingency plans for responding to (i) the accidental discharge of untreated ballast water resulting from a collision or grounding of a vessel in the Great Lakes basin; (ii) the initial discovery of a new alien invasive species in the Great Lakes basin ecosystem; and (iii) the discovery of an alien invasive species in a region previously thought to be free of such organisms. The Commission should also recommend that the Parties clearly identify the responsible agencies and lines of authority for addressing alien invasive species in the Great Lakes basin, and ensure the information is readily available throughout the basin. Further, the Commission should recommend that the Parties facilitate systematic monitoring throughout the Great Lakes basin as a means of assessing the extent of current infestations, as well as facilitating early detection of new alien invasive species.*

I. Introduction

Aquatic and terrestrial ecosystems are of fundamental environmental and economic importance, and perform many beneficial functions, such as nutrient recycling, waste assimilation and water purification. The concept of ecosystems is important because it embodies a key insight about life on earth; namely, that everything is related to and interrconnected to everything else. Thus, actions in one part of an ecosystem can have significant impacts in other parts of the ecosystem.

Events that disrupt ecosystem functions can be natural or human in origin, with potentially serious environmental consequences in either case. Volcanoes, hurricanes and floods are natural events. One serious human-induced ecosystem disruption is the intentional or accidental introduction of living organisms, including phytoplankton, zooplankton, invertebrates, mollusks, viruses, bacteria, protozoa and fish, from one ecosystem into another. In the absence of natural controls, which exist in their original locations (e.g., pathogens, parasites, predators and environmental conditions), introduced nonindigenous or alien species may grow unabated and become established in the new location, seriously disrupting the new ecosystem through the extirpation of native plant and animal species, alteration of existing food chains, and destruction of indigenous biological communities. In fact, after habitat destruction, alien invasive species is the second leading cause of extinction of native aquatic species.

The successful establishment of alien species in a new location can disrupt human water uses, resulting in significant economic impacts, including destruction of commercial and sports fisheries, and interference with or denial of a range of beneficial human water uses such as drinking water, irrigation, hydropower, recreation and others.

II. Alien Invasive Species in the Great Lakes Basin Ecosystem

Alien invasive species have already caused serious environmental problems in major North American water systems, including the San Francisco Bay and Delta, Gulf of Mexico, Chesapeake Bay, upper Mississippi River, and Pacific and Atlantic coastal ecosystems (Ricciardi and MacIsaac, 2000).

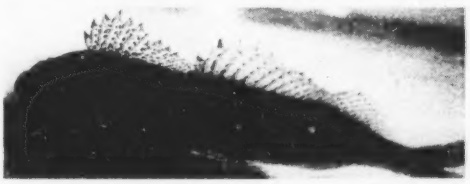
Data collected over the past few decades identify the Great Lakes basin as one of the hardest-hit areas in North America with more than 160 nonindigenous aquatic species becoming established since the early 1800s, particularly since the expansion of the St. Lawrence Seaway in 1959. The problem has become more severe within the past two decades. It is estimated that at least 70 percent of nonindigenous aquatic species discovered in the Great Lakes since 1985 are native to freshwater and brackish water systems in other parts of the world, particularly the Black, Caspian and Azov seas of Eastern Europe (Great Lakes Panel on Aquatic Nuisance Species, 1998; Michigan Department of Environmental Quality, 1999; Ricciardi and MacIsaac, 2000).

Prominent examples of invasive aquatic species that have caused serious environmental and/or economic impacts after their introduction into the Great Lakes basin since the mid-1980s include:

- *zebra mussel (Dreissena spp.)* — Detected in 1988, this small mussel attaches to hard submerged surfaces. It forms densely-layered colonies comprising thousands of organisms per square meter, thereby easily clogging water intake structures of drinking water facilities, irrigation systems and hydropower plants, necessitating expensive and time-consuming removal efforts. It also has had major ecosystem impacts on indigenous mussel populations throughout the Great Lakes basin;

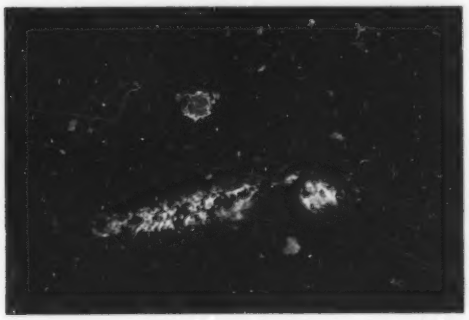
zebra mussels

- *eurasian ruffe (Gymnocephalus cernuus)* — Detected in 1986, this small fish feeds on the eggs of native whitefish and competes with more desirable fish species for available food supplies. Population declines of yellow perch up to 75 percent have been observed in areas where ruffe are established;



eurasian ruffe

- *round goby (Neogobius melanostomus)* — This small fish competes directly with native fish species for available food sources. Detected in 1990, it also is a predator of the eggs and young of native species;



round goby

and

- *fishhook water flea (Cercopagis pengoi)* — This tiny, predacious zooplankton can dramatically affect indigenous plankton populations. Detected in 1998, it competes directly with young fish for the available food supply. In the summer, it can achieve high population densities, forming "clumps" that can entangle the fishing lines of anglers.

fishhook water flea

III. International Joint Commission and Alien Invasive Species

The Boundary Waters Treaty of 1909 between the United States and Canada provides principles and mechanisms to help prevent and resolve disputes along their common border, focusing on water quantity and quality issues. The Treaty also established the International Joint Commission (IJC), giving it the fundamental mandate of assisting the two governments to develop solutions to problems involving transboundary environmental issues referred to it by them. Article IV of the Treaty provided general guidance to the IJC regarding water quality issues, in stating that "*....it is further agreed that the waters herein defined as boundary waters and water flowing across the boundary shall not be polluted on either side to the injury of health or property on the other.*" It is interesting to note that the IJC identified ballast water discharges as an early concern in a 1914 report on pollution of boundary waters. The initial focus was on public health concerns related to the discharge of polluted ballast water near drinking water intakes.

The Great Lakes Water Quality Agreement, originally signed in 1972, revised in 1978, and further amended in 1983 and 1987, also provides substantial guidance regarding relevant IJC activities to address alien invasive species. Article II of the Agreement states that the purpose is "*...to restore and maintain the chemical, physical, and biological integrity of the waters of the Great Lakes Basin Ecosystem,*" including development and implementation of coordinated planning processes and best management "*...to ensure adequate control of all sources of pollution.*" Article VI calls for programs and measures for abatement and control of pollution from shipping sources, including establishment of a "*...coordinated system of surveillance for the enforcement of regulations of oil, hazardous polluting substances, or other pollution*" by the United States and Canadian Coast Guard.

The IJC is also involved with the binational Great Lakes Panel on Aquatic Nuisance Species (1998). This regional panel of the U.S. federal Aquatic Nuisance Species Task Force is developing recommendations to identify Great Lakes priorities, coordinate research, information and education efforts, implement public awareness efforts, and make recommendations to address this problem.

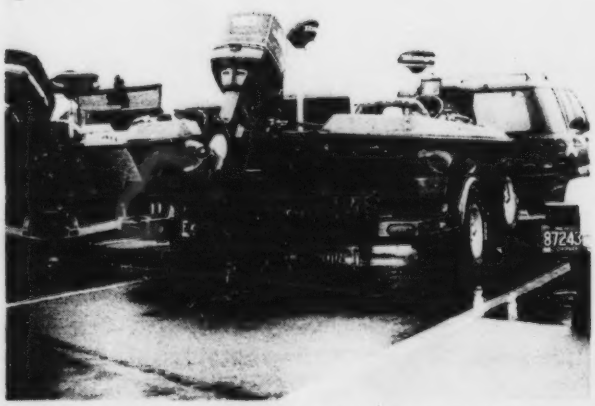
> *"....it is further agreed that the waters herein defined as boundary waters and water flowing across the boundary shall not be polluted on either side to the injury of health or property on the other."*
>
> Article IV of the Treaty

IV. Ballast Water and Alien Invasive Species

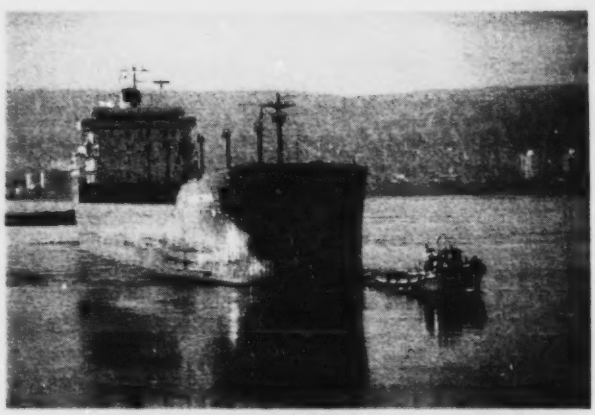
There are many potential sources for alien invasive species to enter the Great Lakes basin, each with its own characteristics. They include:

- ballast water discharged from shipping vessels;
- transport in canal and diversion water flows;
- discard of invasive species used as live bait;
- escape of invasive species from aquaculture activities;
- gardening or horticulture of invasive species;
- discharge or escape of invasive species from aquaria and ornamental ponds;
- sale and use of live invasive species as food organisms;
- creation of transgenic organisms; and
- discharge or escape of invasive species from research and educational facilities.

The Great Lakes Water Quality Board believes all these potential sources deserve more intensive research and evaluation within the context of an ecosystem approach to the problem of alien invasive species. With this document, however, the Great Lakes Water Quality Board wishes to focus the attention of the Commission on one of the major, ***if not the most important***, source for alien invasive species entering the Great Lakes basin ecosystem; namely, the discharge of ballast water from shipping



recreational boats are a significant vector from spreading invasive species

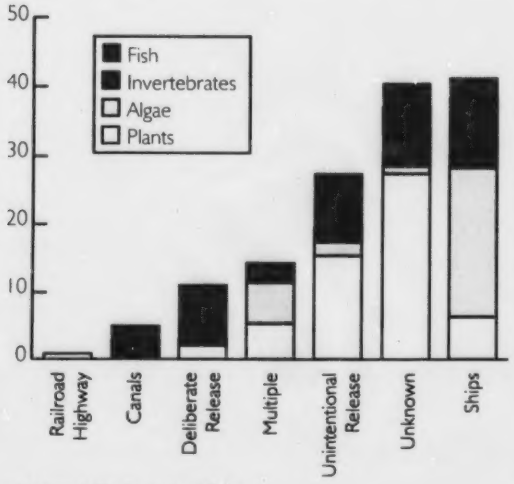


sea-going vessels visit the Great Lakes from all parts of the world

zebra mussels fatally encrust a Great Lakes clam

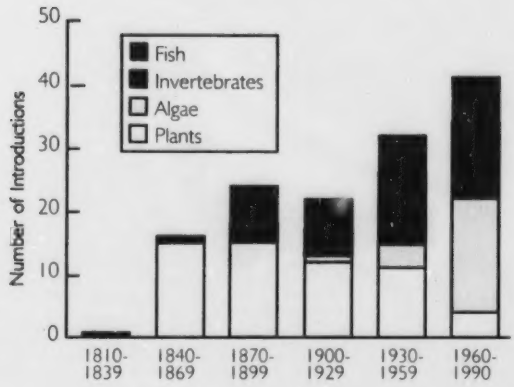
zebra mussels immobilize a Great Lakes crayfish

Entry Mechanisms of Exotic Species into the Great Lakes



Source: Mills, E. et al., 1993.

Timeline of Introductions in the Great Lakes

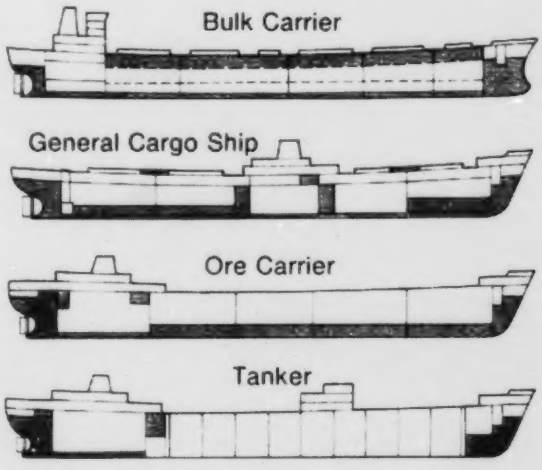


Source: Mills, E. et al., 1993.

vessels entering the Great Lakes. Vessels containing ballast water will inevitably discharge the water, and any aquatic organisms contained in it, at a different location from which it was collected. Thus, all ballast water discharges, particularly those involving water collected at distant locations, carry a risk of introducing alien species into a new aquatic environment, which may be more conducive to their growth and reproduction than their original home. The successful establishment of zebra mussels, round goby and other alien species in the Great Lakes basin in recent years clearly demonstrated the significant environmental and economic consequences associated with this risk. The role of vessels that enter the Great Lakes basin reporting "no ballast on board" is of particular concern in regard to alien invasive species.

The taking on of ballast water is a long standing practice in the shipping industry, as a means of enhancing the safety of ship operation by increasing vessel stability and maneuverability. Because cargo serves the same purpose, a ship loaded with cargo will typically not contain large quantities of ballast water. However, a ship containing ballast water will typically discharge the water when it takes on new cargo.

Ballast Water Capacity of Ocean-Going Vessels Frequenting the Great Lakes



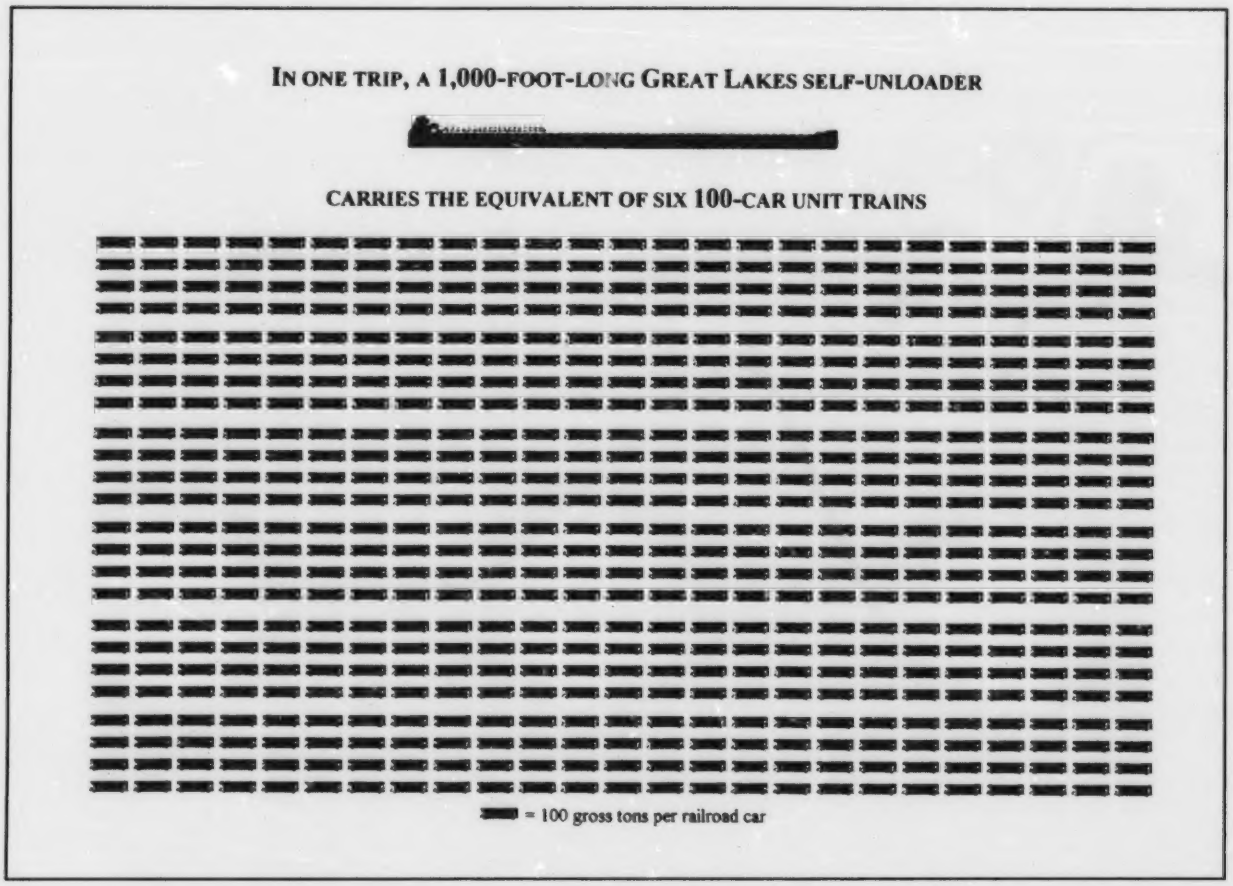
Living aquatic organisms also can be pumped aboard a vessel as it takes on ballast water. A substantial number of these organisms can survive in the ship's ballast tanks and be transported long distances from their original sources. As an example, 367 species of living animals and plants were found in the ballast water of a single ship traveling between Japan and Coos Bay, Oregon (Mackey *et al*, 2000). It is estimated that approximately 10 billion tonnes of ballast water are discharged in different locations around the world each year, and that about 3,000 species are being transported in the ballast water of ships on any given day. When the ballast water is subsequently discharged into a waterbody at a distant location, the surviving aquatic organisms contained are also discharged. If the aquatic organisms become established and reproduce successfully in the new location, major ecosystem disruptions can result, usually to the detriment of the native biological community.

It is estimated that about 75 percent of the nonindigenous flora and fauna introduced into the Great Lakes basin since 1970 can be attributed to ballast water discharges into the Great Lakes from Eurasian ships. Unfortunately, some have resulted in enormous environmental and economic consequences. A growing number of alien aquatic species, for example, already threaten the annual $4.5 billion (US) sports and commercial fishery in the Great Lakes basin. Further, it has cost each large municipal and industrial water user in the Great Lakes basin an average of $360,000 (US) each year to control zebra mussels. It is estimated that zebra mussel control measures have required an expenditure of over $1 billion (US) since 1989. With a continuing influx of vessels from distant ports, there is a significant potential that new invasive aquatic species could be introduced, causing equally serious, or even greater, environmental and economic problems in the Great Lakes basin in the future.

The Great Lakes commercial shipping industry comprises both U.S. and Canadian vessels operating exclusively within the Great Lakes, as well as foreign flag vessels that come to the Great Lakes from every continent and climatic zone in the world. It is estimated that between 500 to 600 foreign flag vessels enter the Great Lakes each year. Because they come from ports outside the Great Lakes, the possibility that these vessels will unintentionally introduce alien invasive species to the Great Lakes via ballast water discharges is enhanced.
It is noted that there is an existing regulatory basis for attempting to address the problem of alien invasive species in the ballast water of vessels entering the Great Lakes basin from outside the U.S. or Canadian Exclusive Economic Zone. Such vessels are currently required to exchange their ballast water outside the 200 nautical-mile Exclusive Economic Zone, ideally in water at least 2,000 meters deep. The U.S. Coast Guard monitors compliance with this requirement by testing the ballast water of all vessels entering the Great Lakes at the Snell Locks at Massena, New York, regardless of their ultimate destination in the Great Lakes basin.

The United States implemented regulations in 1993 to prevent the discharge of untreated ballast water from vessels inbound to the Great Lakes. Inbound vessels have the option of either exchanging ballast water on the open sea with highly saline seawater, retaining ballast water onboard the vessel, using an approved, environmentally-sound alternative disposal method, discharging ballast water to an approved, onshore treatment facility, or exchanging their ballast water in other areas approved by the U.S. Coast Guard.

The rationale for ballast water exchange on the open sea is to exchange ballast water taken from distant locations with saline ocean water, thereby diminishing the possibility that aquatic organisms contained in


IN ONE TRIP, A 1,000-FOOT-LONG GREAT LAKES SELF-UNLOADER
CARRIES THE EQUIVALENT OF SIX 100-CAR UNIT TRAINS
= 100 gross tons per railroad car

the water from the distant location are not subsequently discharged in ports visited by the vessel. The measured salinity of the exchanged water in the ballast tanks provides an indication of the efficacy of the ballast water exchange. Conceptually, the saline water should kill any freshwater organisms pumped aboard with ballast water from the initial location. If the saline ballast water is subsequently discharged in freshwater ports, it is assumed that marine organisms contained in it will not survive in the freshwater environment.

Although ballast water exchange on the open seas as a primary approach for treating ballast water should continue, available evidence suggests that it is not completely effective in preventing the spread of alien invasive species. The configuration of most ballast tank piping systems, for example, and the internal structure of the tanks reduces the efficiency of ballast water pumping. Thus, 100 percent exchange of the ballast water cannot be guaranteed. Further, the structural components in ballast tanks can trap sediment, eggs, cysts and other living components, which can subsequently be released when the "empty" ballast tanks are refilled and their water later discharged in other locations. It also has been found that some freshwater aquatic species have a broad salinity tolerance, and may not be easily killed by the saline ballast water.

There are other complications preventing full compliance with this ballast water exchange requirement. The National Invasive Species Act (NISA) of 1996, for example, contains a safety exemption preventing the U.S. Coast Guard from enforcing ballast water exchange in the open ocean if it would result in unsafe vessel conditions. In such cases, the U.S. Coast Guard requires vessels claiming a safety exemption either to exchange their ballast water at a protected site within the Exclusive Economic Zone, or seal their ballast tanks prior to entering the Great Lakes basin.

U.S. Environmental Protection Agency (EPA) regulations under the U.S. Clean Water Act exempt ballast water discharge from ships (Mackay et *al.*, 2000), thereby allowing vessels to discharge ballast water without a point source discharge permit. The Pacific Environment Advocacy Center is petitioning the EPA to repeal this exemption, suggesting that the Clean Water Act does not give the EPA discretion to exempt ballast water discharges from the permit process, and that ballast water contains biological pollutants as defined in the Clean Water Act. If it ultimately proves successful, vessels discharging ballast water into U.S. waters may require discharge permits under the National Pollution Discharge Elimination System (NPDES), thereby perhaps paving the way for regulating ballast water under the Clean Water Act. The resolution of this petition effort, however, is not clear. Mackay et *al.* (2000) discuss this and other regulatory instruments with possible application to ballast water discharge.

V. The Great Lakes Water Quality Agreement and Alien Invasive Species

The Great Lakes Water Quality Agreement contains several annexes directly relevant to the serious problem of alien invasive species in ballast water discharge to the Great Lakes. Annex 4 of the Agreement, for example, calls for the prevention of discharges of harmful quantities of oil or hazardous polluting substances, including those in ship ballast water. Annex 9 calls for a joint contingency plan for responding to "*...pollution incidents in the Great Lakes System.*" Because alien invasive species can be considered a form of biological pollution, this general principle appears to apply equally well to the environmental impacts of alien invasive species as "polluting" substances. Annex 6 of the Agreement requests the United States and Canadian Coast Guard to review, and study if necessary, the practices and procedures relevant "*..to determine if live fish or invertebrates in ballast water discharges into the Great Lakes constitute a threat to the System.*"

> *"....the IJC's Tenth Biennial Report on Great Lakes Water Quality (2000) recommended that the Parties adopt and implement the binational ballast water research strategy and plan described in the 1996-97 Binational Progress Report on Protection of Great Lakes Water Quality."*

The International Joint Commission and Great Lakes Fishery Commission (1990) previously highlighted alien invasive species as an important issue in the Great Lakes basin, recommending that the Parties require ballast water exchange for ships entering the Great Lakes, coordinate programs, promote international standards, and develop a long-term research strategy. More recently, the IJC's Tenth Biennial Report on Great Lakes Water Quality (2000) recommended that the Parties adopt and implement the binational ballast water research strategy and plan described in the 1996-97 Binational Progress Report on Protection of Great Lakes Water Quality. It further recommended that the Parties give the IJC a reference to develop binational standards for ballast water discharges and appropriate methods for implementing the standards.

Alien invasive species have received major attention in other venues as well. The U.S. Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (NANPCA) provided an institutional framework to (i) promote and coordinate research; (ii) develop and apply prevention and control technologies; (iii) establish national priorities; (iv) educate and inform citizens; and (v) coordinate public programs. The National Invasive Species Act of 1996 reauthorized NANPCA, expanding its scope to include ballast water. The U.S. adopted a regulatory approach to applying the NISA ballast water discharge guidelines. Canada has promoted voluntary guidelines for ballast water exchange. Both countries have penalties for false reporting by shippers regarding their compliance with the ballast water guidelines.

On a global scale, the Parties are working with the International Maritime Organization (IMO) to develop effective international standards for discharged ballast water. This effort, however, is proceeding at a very slow pace. The IMO is also currently drafting a new Annex to MARPOL 73/78, introducing mandatory regulations. Further, the United Nations Convention on the Law of the Sea requires signatory nations to take all measures necessary to prevent, reduce and control the intentional or accidental introduction of alien or new species to any part of the marine environment that may cause significant or harmful changes thereto. Although recent data suggest a strongly one-sided movement of alien invasive species to the Great Lakes from other regions, these global activities are nevertheless relevant within the context of the Great Lakes basin representing both a *recipient* for alien invasive species from abroad, as well as a potential *source* to other regions of the world.

VI. Ballast Water and NOBOBs

Approximately 80 percent of the foreign flag vessels entering the Great Lakes each year report "no ballast on board". Commonly called NOBOBs, they presumably contain no ballast water. However, even vessels with supposedly empty ballast tanks can retain a significant portion of their original ballast water volume. Although they typically contain a substantial quantity of residual ballast water and sediment, NOBOBs are not bound by the open-sea ballast water exchange regulations applicable to ballasted vessels. Available data suggests this residual volume can vary between 59 to 468 metric tonnes, with an average of 158 metric tonnes per vessel.

The basic problem with NOBOB vessels is that they typically take on ballast water where they unload their cargo. This ballast water can subsequently mix with the unpumpable residual ballast water and sediment in their ballast tanks. If the ballast water mixture remains in the vessel, no environmental damage will occur. However, after its initial cargo is unloaded, a NOBOB vessel typically will take on cargo at another port in the Great Lakes basin, thereby requiring it to discharge its ballast water mixture, including any living aquatic organisms contained in it. It is estimated that approximately 40 percent of NOBOBs in the Great Lakes basin will fill their ballast tanks with water from one location, and subsequently discharge their ballast water in a different location within the basin. Thus, foreign NOBOB vessels must be categorized as a primary source for the introduction of alien aquatic species to the Great Lakes basin. In contrast, in-lake vessels are more likely to move aquatic organisms from one location to another within the Great Lakes basin. Vessels engaged in coastal trade inside the United States and Canadian Exclusive Economic Zone likely lie somewhere between these extremes.

VII. Treatment Alternatives for Ballast Water

There are several alternative methods for attempting to address the problem of alien invasive species associated with ballast water, including:

- **reducing alien invasive species taken on board;**
- **retaining ballast water on board;**
- **exchanging ballast water at sea;**
- **treating ballast water onboard ships; and**
- **creating ballast water in onshore facilities.**

The Great Lakes Water Quality Board believes a preventative approach is always preferable to trying to cope with a problem after it has occurred. Experience has indicated again and again that it invariably costs less to implement a preventative approach than a reactive approach. A preventative approach to alien invasive species can significantly reduce the overall ecosystem damage. Further, successful invasions of alien aquatic species are even more difficult to clean up contaminants in water. Accordingly, prevention of alien invasive species being discharged with ballast water can take the form of reducing or eliminating the possibility of taking living aquatic organisms onboard in the first place, or alternatively insuring either that the ballast water is not discharged or is only discharged after appropriate treatment to kill any living aquatic organisms it contains.

Filtration

Possible actions at the source of the ballast water focus on reducing or eliminating aquatic organisms in the ballast water pumped into a vessel's ballast tanks. One possibility for the ballasting phase is to filter the incoming ballast water, thereby preventing the uptake of aquatic organisms with the ballast water. If the ballast water contains no living aquatic organisms, it can safely be discharged in other locations. Filtration also can be used to treat ballast water prior to its discharge.

Available data suggest that filtration is effective for filtering sediments and aquatic organisms out to a length of about 20-100 microns, and that it is 95-99 percent effective against zooplankton and 60-80 percent effective against smaller planktonic organisms (Mackay *et al.*, 2000). Identified limitations to filtration include the size and cost of the needed equipment, the large water volume to be filtered, its efficacy under different operating conditions, and its ineffectiveness in addressing microbial and viral contaminants. Accordingly, the Great Lakes Water Quality Board welcomes the ongoing studies directed to evaluating and quantifying the effectiveness of filtration as a control option for alien invasive species, which is being conducted by the Northeast-Midwest Institute on behalf of the Great Lakes Governors, via funding from the Great Lakes Protection Fund. When completed, these studies should provide valuable data and information on the overall utility of this approach for the Great Lakes basin.

zebra mussels encrust an intake pipe

Ballast Water Exchange

Several onboard treatments are applicable to vessels enroute to the Great Lakes. The most commonly applied method is the previously identified ballast water exchange on the open sea, ideally done outside the 200 nautical-mile Exclusive Economic Zone, in waters at least 2,000 meters deep. However, the inability to ensure 100 percent flushing of the ballast tanks, and the broad tolerance of many

aquatic species to saline ocean water, are limitations to this approach. The ability of NOBOBs to retain a significant quantity of residual ballast water, as well as eggs, cysts and other living biological material that can be discharged with the ballast water, also continues to constitute a limitation to this approach.

Ultraviolet Light

Onboard treatment possibilities focus on disinfecting the ballast water. One method is the use of ultraviolet light to kill living aquatic organisms. However, because the water must be virtually free of suspended particles for this to be effective, it has been proposed primarily as a secondary treatment for ballast water that has already been filtered. It is subject to the same flow, volume and operating limitations as filtration, although it appears to be more effective for killing bacteria and viruses.

Heat

Another approach is to heat the ballast water to a temperature that will destroy living aquatic organisms contained in it. However, in additional to requiring a lengthy treatment time, this method also requires a reliable heat source for treating large volumes of ballast water. It also does not appear to be effective against many bacteria and viruses.

Ozone

Ozone has been suggested as a ballast water disinfectant. However, ozone can react with bromides in seawater. Accordingly, its optimal use may be restricted to vessels already confined to the Great Lakes basin.

Biocide Chemicals

The use of biocide chemicals to disinfect ballast waters also is being evaluated. This approach involves dosing ballast water with sufficient levels of chemicals to kill living aquatic organisms contained in it. Several candidate chemicals being evaluated at the present time include hypochlorite (chlorine), gluteraldehyde and paracetic acid. Other candidates may exist.

Onboard Retention

A direct approach for application to vessels already within the Great Lakes is to physically retain the ballast water onboard the ships during their passage. However, restricting a ship from discharging ballast water when it takes on cargo also restricts its maximum cargo load, with economic consequences.

Onshore Treatment

Another alternative is to discharge the ballast water into onshore treatment facilities. However, there are presently few onshore treatment facilities in the Great Lakes basin capable of handling the large volumes of ballast water from shipping vessels. Therefore, a major capital investment in onshore water reception facilities would be required to avoid serious disruption of commercial vessel operations. Vessels also would have to be modified to pump ballast water ashore. Consequently, this option is generally not considered economically feasible at this time.

Needed Research

Research on other possible sources of alien invasive species, as well as their life cycles and potential interactions with indigenous biological communities, is urgently needed. The successful invasion by round goby in the Great Lakes basin, for example, followed the successful invasion by zebra mussels, its primary food source. It is reasonable to assume, therefore, that future infestations may "piggyback" on previous successful infestations. There are doubtless more subtle relations between the spread of alien invasive species and such generic issues as climate change and human health.

VIII. Recommendations

Recommendations for Addressing Ballast Water as a Source of Alien Invasive Species to the Great Lakes Basin

Given the economic importance and magnitude of the Great Lakes shipping industry, the Great Lakes Water Quality Board acknowledges that there is no easy solution to the problem of alien aquatic species in ballast water. In fact, a mix of measures may ultimately be required to adequately address this problem. Nevertheless, recent successful invasions of the Great Lakes basin ecosystem by nonindigenous aquatic species have already caused major ecosystem disruptions, as well as significant economic consequences, that cannot easily be reversed. Research also highlights the significant potential for future successful invasions. It is estimated, for example, that the potential exists for up to 33 new alien species to invade the Great Lakes basin ecosystem in the foreseeable future, primarily from the Ponto-Caspian region (Ricciardi and MacIsaac, 2000).

The Great Lakes Water Quality Board acknowledges, and does not wish to duplicate, the actions already undertaken by the Parties and others to address the issue of alien invasive species in the Great Lakes basin. At the same time, however, the board believes that many of these actions are uncoordinated and inconsistent. An obvious inconsistency, for example, is the application of a regulatory versus voluntary approach to ballast water exchange requirements in different portions of the basin. Accordingly, the Great Lakes Water Quality Board believes a comprehensive, preventative binational approach is a fundamental requirement for insuring necessary actions to combat this serious problem in the Great Lakes basin are undertaken in an expeditious, efficient and cost-effective manner. The fact that the Great Lakes basin is both a *recipient* for alien invasive species from abroad, as well as a potential *source* of alien invasive species to other locations further highlights the importance of properly addressing this problem.

The Great Lakes Water Quality Board offers several recommendations to the Commission regarding ballast water and alien invasive species, and highlights the need for acquiring additional data and information to increase our understanding of the overall problem, and to assist the Parties in developing long-term, environmentally-compatible solutions.

(A) Binational ballast water discharge standards

The Great Lakes Water Quality Board recognizes the technical difficulties in preventing the introduction of alien invasive species into the Great Lakes basin via ballast water exchange. The particular role of NOBOBs, which comprise about 80 percent of the vessels entering the Great Lakes from foreign ports and which are not subject to the mandatory testing and enforcement action associated with ballasted vessels, in exacerbating the problem was previously highlighted. Accordingly, some means of addressing the residual ballast water problems associated with NOBOBs is urgently needed.

The Great Lakes Water Quality Board believes the most direct way to protect the Great Lakes from the introduction of alien invasive species in ballast water is to develop and enforce binational ballast water discharge standards that must be met by all vessels discharging ballast water in any form or location within the Great Lakes basin. Effective application and enforcement of binational ballast water discharge standards will help ensure alien invasive species from this source do not become successfully established in

the Great Lakes. To this end, the board also acknowledges, and awaits the outcome of, the work being undertaken by the Ballast Water and Shipping Committee of the Aquatic Nuisance Species Task Force to develop a realistic standard for ballast water discharges. When developed, the board believes the Parties should seriously consider its application throughout the Great Lakes basin.

- ***As the core of a preventative, binational approach for addressing the serious threat of alien invasive species (AIS) in the Great Lakes basin, the Commission should recommend to the Parties that effective binational ballast water discharge standards be developed, implemented and enforced throughout the Great Lakes basin as rapidly as possible. Further, the Commission should recommend the Parties prohibit the discharge of ballast water of any type into the Great Lakes basin from ballasted vessels and from vessels reporting no ballast on board (NOBOBs), whatever their origin, that do not meet the binational standards while they are within the Great Lakes basin.***

(B) Technologies to achieve ballast water discharge standards

The Great Lakes Water Quality Board recognizes that it may be decades before technologies to achieve effective ballast water discharge standards are developed and applied. Therefore, in order to expeditiously implement and enforce standards, additional resources must be directed immediately to the development and testing of effective long-term ballast water treatment technologies. This will require more intensive efforts on the part of the Parties, shippers and other relevant stakeholders.

Additional research on the life cycles of alien species that have invaded, or which may invade the Great Lakes basin ecosystem in the future is needed. Greater knowledge on this topic will assist the Parties in determining the most vulnerable or sensitive stage in the life cycle of alien species where specific prevention or control technologies may be most effective. Equally important is knowledge of the potential interactions of alien species with indigenous species, and how these interactions may facilitate successful invasions. Research efforts directed to preventing the spread of alien invasive species to other waterbodies, both inside and outside the Great Lakes basin, also are needed.

- ***To aid in achieving the binational ballast water discharge standards, the Commission should recommend that the Parties, in cooperation with shippers and other relevant stakeholders, facilitate an immediate and significant investment in resources directed to the development of effective, long-term ballast water treatment technologies (e.g., filtration, ultraviolet light, heat, ozone), either onboard vessels or through onshore facilities. The Parties should also facilitate research directed to studying the life cycles of alien species with the greatest potential for invading the Great Lakes basin ecosystem, including identification of their potential interactions with, and impacts on, indigenous aquatic species.***

Recognizing the continuing threat of alien invasive species, while long-term development work continues on a fast-track pace, the Great Lakes Water Quality Board believes the Parties should consider the use of chemical treatment on a short-term, emergency basis as a stop-gap measure to combat the spread of invasive species via ballast water discharges.

- ***Until acceptable long-term treatment technologies are developed for treating ballast water to achieve the binational discharge standards, the Commission should recommend that the Parties give serious consideration to chemical treatment of ballast water as a short-term, emergency measure for all vessels entering the Great Lakes from outside the Exclusive Economic Zone. To facilitate the short-term, emergency use of chemical treatment, the Commission should recommend that the Parties, in cooperation with shippers and other relevant stakeholders, undertake appropriate testing and evaluation activities to determine the efficacy of alternative chemicals, including effective biocide chemical dosages, relative costs, onboard handling requirements and vessel safety, and potential environmental impacts of treated ballast water discharges. The Parties should develop and apply a uniform protocol for evaluating the results from the testing and evaluation program for application throughout the Great Lakes basin.***

(C) Best management practices for sediment control

The presence of sediment in ballast tanks interferes with virtually all technologies currently being considered for treating ballast water for alien invasive species. Thus, sediment can interfere with achievement of binational ballast water discharge standards, by directly interfering with treatment process(es) being applied. It also can become encrusted on cross members, beams and other physical structures within ballast tanks, providing a medium for trapping cysts, eggs and other forms of aquatic life, which can subsequently be released in ballast water discharges. The Great Lakes Water Quality Board believes, therefore, that implementing best management practices for sediments will facilitate achievement of binational ballast water discharge standards. It also believes that vessels employing best management practices are likely to be more amenable to implementing other control measures for alien invasive species in ballast water. As an example, shippers previously voluntarily reduced the speed of vessels in the St. Lawrence Seaway to reduce shoreline erosion. Implementing best management practices for sediment control represents a similar positive action on the part of shippers and will contribute to enhancing the state of the Great Lakes basin ecosystem. To this end, the Great Lakes Water Quality Board believes that the Parties should publicly recognize shippers employing best management practices for sediments, as a positive achievement to be emulated.

- ***The Commission should recommend to the Parties that shippers and other relevant stakeholders immediately implement best management practices for ballast tank sediment control for all vessels entering the Great Lakes basin. The Commission should also recommend that the Parties undertake a program to publicly recognize the efforts of shippers engaged in good management practices.***

(D) Shipping vessel design modifications

Involvement of the shipping industry is essential for addressing the problem of alien invasive species in ballast water. With this observation, the Great Lakes Water Quality Board supports the general principle of allowing the shipping industry some flexibility regarding methods to be employed to address this

problem, including consideration of the particular role of NOBOBs in this process.

Ship design is an important consideration for enhancing the efficacy of alternative technologies to achieve ballast water discharge standards. Inappropriate siting of pump intakes and water outlets in ballast tanks, for example, is a major constraint to complete flushing of vessel ballast tanks in open-sea ballast water exchange. Thus, appropriate ship design can facilitate the effective application of the various technologies being considered for disinfecting ballast water, both for existing and future vessels. Further, in considering vessel design modifications, including both retrofitting existing vessels and in designing new vessels, any requirements of the Parties should be consistent with other proposed international standards.

The Great Lakes Water Quality Board notes that the International Maritime Organization (IMO) is studying the issue of vessel design modification. Although the pace of discussion continues to be slow, the board urges the Parties to assist the IMO to the maximum extent in its relevant activities on this issue.

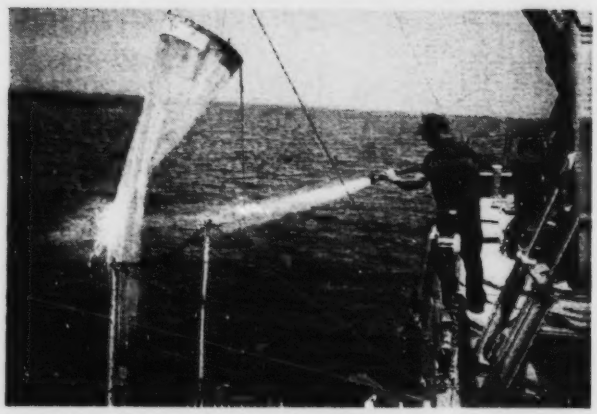
- ***The Commission should recommend to the Parties that, as rapidly as possible, shippers incorporate vessel design modifications as appropriate for existing and new vessels, as a means of facilitating ballast water exchange on the open seas, and the effectiveness of other measures being considered (e.g., chemicals, filtration, ultraviolet light, heat) for treating ballast water to meet binational discharge standards. The Commission should also assist the Parties as appropriate in their interactions with the International Maritime Organization on the issue of vessel design modifications as a means of addressing the problem of alien invasive species in ballast water.***

(E) Contingency plans for alien invasive species

The Great Lakes Water Quality Board commends the various efforts undertaken by the Parties, shippers and environmental nongovernmental organizations to address the problem of alien invasive species in the Great Lakes basin ecosystem. However, the board also believes these efforts are generally characterized by differing goals, programs, resources and timetables, resulting in inconsistent and uncoordinated actions. Equally problematic is the lack of clear guidance regarding the myriad of state, provincial and federal agencies with authority for various aspects of this issue, as well as the role of the multiple commissions, panels and environmental nongovernmental organizations involved in it. As a result, it is difficult to identify what agency(ies) are addressing what aspects of this issue, thereby insuring confusion in identifying problems and implementing appropriate follow-up actions to the discovery of new alien invasive species in the Great Lakes.

The Parties are responsible for developing comprehensive local, regional and joint contingency response plans to address discharges of oil and hazardous substances into the Great Lakes basin associated with shipping vessels, as outlined in Annexes 5, 6 and 9 of the Great Lakes Water Quality Agreement. It is a next logical step, therefore, to ensure that emergency situations involving alien invasive species are handled with the same priority as discharges of oil and hazardous polluting substances. Clear procedures and lines of responsibility must be identified for appropriate discovery, response and enforcement actions to this problem. It is not too dramatic to envision some type of alien invasive species "SWAT team" approach, with the capability to respond rapidly to identification of new alien species in the Great Lakes basin, including appropriate monitoring, assessment and control measures.

- *The Commission should recommend that the Parties develop and implement effective contingency plans for responding to (i) the accidental discharge of untreated ballast water resulting from a collision or grounding of a vessel in the Great Lakes basin; (ii) the initial discovery of a new alien invasive species in the Great Lakes basin ecosystem; and (iii) the discovery of an alien invasive species in a region previously thought to be free of such organisms. The Commission should also recommend that the Parties clearly identify the responsible agencies and lines of authority for addressing alien invasive species in the Great Lakes basin, and ensure the information is readily available throughout the basin. Further, the Commission should recommend that the Parties facilitate systematic monitoring throughout the Great Lakes basin as a means of assessing the extent of current infestations, as well as facilitating early detection of new alien invasive species.*



rinsing plankton net on the University of Michigan research vessel, "Laurentian"

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